

Influence of varying environmental conditions on biennial bearing habit of Kinnow fruit (*Citrus nobilis* Lour x *C. deliciosa* Tenora) grown at different clusters in the Punjab province, Pakistan

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SUMMARY

Influence of varying environmental conditions on biennial bearing of Kinnow mandarin was assessed at three main citrus clusters in the Punjab province, Pakistan. The selected orchards of identical features are located in districts Sargodha, Toba Tek Singh (TTS) and Vehari. The experiment was laid out in randomized complete block design by using analysis of variance technique. Fruit bearing habit was recorded first and second seasons and biennial bearing trend was observed at TTS and Vehari. Vegetative three flushes were slightly changed due to biennial bearing in warm districts TTS and Vehari. More evenness in fruit yield and quality parameters was recorded at Sargodha while significant change was observed at TTS and Vehari. Timely harvesting of orchards at Sargodha district showed regular fruit-bearing in both seasons and delayed harvesting induced biennial bearing trend more at TTS and Vehari. More physiological and ripening stage fruit drop was observed in warm conditions of Vehari and TTS while an increasing level was recorded in rainy season at Sargodha with insignificant differences in both seasons.

Index terms: *Citrus nobilis* x *C. deliciosa*, alternate bearing, varying environmental conditions.

Influência das variáveis ambientais na bienalidade produtiva de tangerina Kinnow (*Citrus nobilis* Lour x *C. deliciosa* Tenora) cultivada em diferentes províncias de Punjab, Paquistão

RESUMO

A influência de diferentes condições ambientais no manejo da alternância de produção da tangerina Kinnow foi avaliada em três principais regiões produtoras de citros na província de Punjab, Paquistão. Os pomares selecionados de características idênticas estão localizados nos distritos Sargodha, Toba Tek Singh (TTS) e Vehari. O experimento foi instalado em delineamento de blocos casualizados, utilizando a técnica de análise de variância. O hábito de frutificar foi registrado na primeira e segunda temporadas e a tendência de alternância foi observada no TTS e Vehari. As três descarga vegetativas foram levemente alteradas devido à presença bienal nos distritos quentes TTS e Vehari. Mais uniformidade nos parâmetros de produção e qualidade dos frutos foi registrada em Sargodha, enquanto mudanças significativas foram observadas em TTS e Vehari. A colheita oportuna de pomares no distrito de Sargodha mostrou frutificação regular em ambas as estações e a tendência de alternância de produção induzida pela colheita atrasada mais no TTS e Vehari.

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Observou-se maior queda fisiológica e de frutos maduros nas condições quentes de Vehari e TTS, enquanto um nível crescente foi registrado na estação chuvosa em Sargodha, com diferenças insignificantes nas duas estações.

Termos de indexação: *Citrus nobilis* x *C. deliciosa*, alternância de produção, condições ambientais variáveis.

INTRODUCTION

Kinnow mandarin is hybrid of King (*Citrus nobilis* Lour) and Willow (*Citrus deliciosa* Tenore) has been introduced in the Subcontinent during the dwindling era of British in 1942 at Lyallpur Agriculture College, now named as University of Agriculture Faisalabad and acquired commercialization in 1960's with start of export in 1990's. Now this fruit has monopolized citrus industry of Pakistan with 91% area and same level of production. It is mainly growing in four main clusters of the Punjab province led by in central to northern side Sargodha and adjacent districts (M.B Din and Chiniot) with 60-62% area, followed by central Punjab district Toba Tek Singh and adjunct area (Faisalabad and Jhang) with 10-12% area and in Southern side of the Punjab (Vehari, Sahiwal and Khanewal) with 15-18% share in area and newly emerging fourth cluster in Thal districts of western side of the Punjab (Bhakhar and Layyah) with 5-6% area (Ghafoor et al., 2008; Pakistan, 2017; Nawaz et al., 2019a, 2019b).

Kinnow mandarin is exclusive exportable citrus of Pakistan by touching worth of 222 million US dollars and 370 thousand tons during the season 2017-18 (Nawaz et al., 2019b, 2019c). It is highly valuable crop of country by employing huge labors and rich source of income to farmers' community. Pakistan just export (10-12%) of her total Kinnow fruit produce while rest is consumed at domestic markets (TDAP, 2018; PHDEC, 2018). Fruit quality is top most priority of buyers while purchasing fruits either to sell at domestic markets or to processing units for export purpose. In light-bearing year, growers, consumers and processors of Kinnow fruits are more at risk with low income to farmers, costly fruit for consumers and mediocre quality for export (TDAP, 2017). Pakistani Kinnow is excellent in outlook, quality, flavor and taste when compared to fresh mandarin across the world but due to export barriers and rigorous certifications process, just fetch 2% in high returning markets of EU and advanced countries (Ahmed, 2005). Climate change has increased risk of citrus fruit grown in different clusters with more pests pressure and matured fruit drops at warm conditions (Nawaz et al., 2020b) along with more accretion of agrometeorological indices (Nawaz et al., 2020a) and

increasing level of pest-diseases (Nawaz et al., 2019a). Citrus fruit quality is maintained through management of orchard (Mahmood & Sheikh, 2006) and also minimizing biennial bearing. Similarly, external environmental conditions can decide fruit external and internal quality (Ladaniya, 2011), in addition citrus fruit bearing habit,

In era of increasing trend of greenhouse gases to rise earth temperature (IPCC, 2007) has increased abiotic and biotic stress on crops (Ullah et al., 2015) and also on citrus (Nawaz et al., 2019a). More fruit drop is seen in extreme weather conditions like heat-wave and smog time (Nawaz et al. 2020b) by directly affecting on-tree fruit quantity and subsequent season bearing habit (Wheaton, 1992). More alternate bearing and quality deterioration are seen in climate change era (Zekri, 2011) and altered agricultural systems and crop preference (Parry et al., 2004). Strategies of different nature are explored to mitigate environmental detrimental effects on annual crops (Burton & Lim, 2005) with little focus on perennial fruits with exception of citrus Valencia orange regarding yield (Tubiello et al., 2002). Being a perennial fruit, citrus stand many years in field is become more vulnerable to vagaries of weather due to slow adoption in changing climatic variables (Jones et al., 2005), is more inclined toward irregular bearing with dented fruit quality (Hield & Hilgeman, 1969).

Irregular bearing habits produce heavy crops in first year and light in second is termed as alternate or biennial bearing (Monselise & Goldschmidt, 1982) that is the leading cause of imperfection marketing of irregular supply mechanism. Similarly, glut of fruit in markets during on-year delay harvesting time with less flowering and low fruit-setting while light bearing crop earlier harvested to induce more fruiting for coming season. This phenomenon is termed as alternate bearing to affect citrus orchard productivity and profitability (Davis et al., 2004) along with marketing issues like superfluity; uneven supply and price oscillation (Moss et al., 1974). In Pakistan, biennial bearing impinge on supply-chain by recording 40% (Johnson, 2006) and 35% fruit loss (Khan, 2008) with recoding more profit margin of brokers, buyers and exporters during heavy bearing season (Usman et al., 2018).

Present study was designed in main Kinnow growing districts Sargodha, TTS and Vehari of representing three main citrus clusters in the Punjab province. Field based study was designed to select identical features Kinnow plants and survey to citrus stakeholders perception. Impact of varying environmental conditions on fruit bearing habit was analyzed.

MATERIALS AND METHODS

The present study was conducted in three main citrus growing districts of the Punjab province, Pakistan namely Sargodha (32.0837° N, 72.6719° E) altitude 189 m, Toba Tek Singh (30.9727° N, 72.4850° E) altitude 161 m and Vehari (30.0452° N, 72.3489° E) altitude 140 m. The research work performed in first season (2017-18) and second season (2018-19).

Selection of orchards

Identical plants characteristics like age, planting density and grafted on rootstock (Rough lemon) were chosen (Nawaz et al., 2020b) while tagging 36 branches/twigs at different canopy positions (Nawaz et al., 2020a) to record data on monthly basis.

Climatic/weather data

Climatic/weather data of Sargodha and TTS was taken from Pakistan Meteorological Department and Vehari from the office of Deputy Director Agriculture (Extension) Vehari.

Measurement of bearing habit

Three orchards were selected in each district to count bearing habit of 100 Kinnow plants in each orchard in growing season 2017-18 and 2018-19 and calculated number of light, medium and heavy bearing plants.

Flush quantification

In selected orchards, vegetative three flushes were quantified by using a quadrat (0.5×0.5×0.5m³) and counted twigs inside and value expressed in percentage.

Fruit yield and grades percentage

In selected orchards fruit yield and grades percentage were calculated at harvesting by counting number of fruits and grades (A, B and C) percentage.

Orchard harvesting trend

A survey in selected clusters was performed to investigate harvesting timing during both seasons.

Fruit drop trend

Fruit drop percentage of three distinct stages, physiological (April-May), rainy season (June to September) and maturing (October-December) was calculated from tagged branches.

Statistics design

Three biological replicates were selected in a randomized complete block design by using analysis of variance technique on Statistix 8.1 software by keeping LSD value ≤ 5% significance level.

RESULTS AND DISCUSSIONS

Data analysis showed significant economic impact on citrus (Kinnow mandarin) during on-year and off-year, which was explained and discussed under.

Weather data of three locations

Monthly basis average data of three selected sites showed clear-cut differences in temperature, relative humidity, rainfall and actual sunshine hours. Annual higher temperature was recorded at Vehari (27.11 °C), followed by TTS (25.19 °C) and lower at Sargodha (24.34 °C). Annual humidity was recorded (66.80 and 66.51%) at Sargodha and TTS and lower (55.64%) at Vehari (Table 1). Maximum average rainfall on monthly basis was recorded at Sargodha (42.16mm), followed by TTS (29.15mm) and lower at Vehari (12mm). Average monthly basis, more actual sunshine hours were counted

Table 1. Weather data of three districts (Pakistan)

Months	Weather data of three research sites											
	Average temperature (°C)			Average relative humidity (%)			Rainfall (mm)			Actual sunshine (hours)		
	SGD*	TTS	VEH	SGD	TTS	VEH	SGD	TTS	VEH	SGD	TTS	VEH
Jan	12.17	12.76	14.13	80.05	81.05	73.68	18.84	5.41	7.50	114.60	145.70	155.25
Feb	16.34	16.80	17.26	65.93	63.48	61.65	14.02	6.41	5.50	188.80	190.95	198.75
Mar	21.62	22.13	24.94	63.68	65.32	57.98	26.30	13.96	3.50	222.15	219.65	234.31
Apr	27.56	28.73	31.24	53.67	51.27	41.03	73.59	44.73	1.00	250.70	237.15	250.80
May	31.56	32.39	35.83	49.35	46.98	32.85	39.03	21.37	2.00	256.05	230.65	255.31
Jun	32.59	32.80	35.78	59.00	62.85	40.70	58.84	48.96	38.50	215.25	189.05	255.25
Jul	31.57	32.96	33.20	72.47	71.37	55.22	167.17	102.46	81.00	211.75	218.80	230.45
Aug	31.98	32.62	33.03	70.87	68.76	55.73	52.53	79.06	1.00	214.95	208.45	238.75
Sep	29.66	30.78	33.88	70.63	67.13	51.87	49.02	20.96	0.00	230.95	222.55	233.90
Oct	25.56	26.93	29.65	63.76	64.60	61.00	3.01	0.01	0.00	225.10	229.55	239.40
Nov	18.03	18.84	19.78	80.02	82.40	64.42	1.53	2.51	0.00	187.40	151.20	158.75
Dec	13.43	14.56	16.65	72.23	72.94	71.60	7.52	4.06	4.00	199.95	184.78	196.3
Avg	24.34	25.19	27.11	66.80	66.51	55.64	42.61	29.15	12.00	209.80	210.60	220.95

*Abbreviation: SGD (Sargodha), TTS (Toba Tek Singh), VEH (Vehari).

at Vehari (220.95 hours), followed by (210.6 hours) at TTS and less in Sargodha (209.8 hours) (Table 1).

Vehari is located in southern side of the Punjab province has dry warm conditions having more temperature and low humidity from April till September than other districts and low rainfall. As Sargodha is located in northern side has low temperature and more rainfall and less sunshine hours. Whereas, annual humidity level of TTS is equal to Sargodha having slightly high temperature and significantly less rainfall when compared with Sargodha. All three sites showed climatic variations which directly influenced on fruit growth phases and plant physiology.

Measurement of bearing habit

Among different bearing habits out of selected 100 plants orchards, maximum heavy-bearing plants were recorded at district Vehari (30), followed by TTS (25) and less in Sargodha (10) during first season and in second season heavy-bearing plants were observed in Sargodha (15) followed by TTS (10) and less at Vehari (8). Medium-bearing plants were recorded more at Sargodha (70 and 55), followed by TTS (60 and 50) and less in Vehari (55 and 45) during first and second seasons, respectively. Low-bearing plants were counted in Sargodha (20 and 30), TTS (15 and 40) and Vehari (15 and 47), respectively during first and second seasons. Data are shown in Table 2.

Biennial bearing habit occur to individual plant or within a plant few branches or to whole block in cluster (Monselise & Goldschmidt, 1982) with more trend is seen in mandarin group of citrus (Wheaton, 1992). In Vehari and TTS, Kinnow fruit is mainly consumed at domestic markets with start of late harvesting and more intensity in heat-wave started during onset of summer spell with recording more fruit drop. Resultantly, more phenomena of biennial bearing observed were observed in these warm districts. In Sargodha, Kinnow fruit exporting units start earlier and spot-picking of fruit has reduced load as well as timely harvesting yielded more evenness in bearing habit which was recorded in present study. Goldschmidt & Golomb (1982) reported that heavy-bear citrus plant lack flowering for next year and cause alternate bearing habit. Heavy-bearing plants were more recorded at Vehari and TTS in first season and low-bearing in second season. Timely harvesting and more medium-bearing plants were recorded at Sargodha, resulted in less biennial bearing issues. Timely harvesting and medium-bearing citrus plants maintain a balance in floral and vegetative flush with evenness habit of fruit bearing (Garcia-Luis et al., 1995) to justify present work.

Flush quantification

Three different flushes viz; spring, summer and fall were quantified during growing first and second seasons with showing a significant statistical difference in Table 3.

Table 2. Bearing habit of Kinnow fruit in first and second season under varying environmental conditions

	Sargodha		T.T Singh		Vehari	
	First season	Second season	First season	Second season	First season	Second season
Heavy-bearing (No. of plants)	10±2	15±3	25±2	10±2	30±2	8±2
Medium-bearing (No. of plants)	70±2.83	55±1.73	60±1.16	50±1.16	55±2	45±1.16
Light-bearing (No. of plants)	20±1.41	30±3.51	15±2.89	40±1.15	15±1.41	47±6.24

Data are presented in means (±SD). SD = standard deviation.

Table 3. Quantification of vegetative flushes during first and second seasons

	Sargodha		T.T Singh		Vehari	
	First season	Second season	First season	Second season	First season	Second season
Spring flush (%)	60±2	62±2.53	50±2	56±2	55±3	60±2
Summer flush (%)	30±2	26±1.13	35±2.65	30±1.53	32±4.36	28±1
Autumn flush (%)	10±2	12±1.53	15±3	14±1.53	13±2.65	12±1

Data are presented in means (±SD). SD = standard deviation.

In first season, spring flush was recorded (60, 50 and 56%), summer flush (30, 35 and 32%) and autumn flush (10, 15 and 13%) at Sargodha, TTS and Vehari districts, respectively. In second season, spring flush was recorded (62, 56 and 60%), summer flush (26, 30 and 28%) and autumn (12, 14 and 12%) in districts Sargodha, TTS and Vehari, respectively.

Dalal et al. (2013) recorded maximum spring and minimum autumn flush of Kinnow mandarin. Bower (2007) attributed summer flush lower than spring due to hard environmental conditions in summer season. In present work, spring flush in both season and all three districts counted more than half of total annual flush with one-third to one-fourth share of summer and less contribution of autumn flush. No significant differences were observed at Sargodha districts in three vegetative flushes but slight variations were seen at TTS and Vehari in spring and summer flushes due to biennial bearing habits. More summer flush was recorded at TTS and Vehari as warm conditions earlier accrued growing degree days as required for fruit cell division. Similar results in citrus are observed by Sharma et al. (2017) of recording prior cell division completion and starting of cell enlargement in warm conditions grown fruits. In current work, both cell division and cell enlargement commenced prior to Sargodha in districts TTS and Vehari with earlier sprouting of summer flush vegetative growth. More summer flush was recorded in second season due to low bearing of Kinnow fruit at TTS and Vehari while evenness in all three flushes quantification was seen at Sargodha.

Photoassimilates more streamlined towards fruit growth and development, yielded low quantification of summer and spring flushes in heavy cropping season (Iglesias et al., 2007). Resulting, less growth in summer and fall flushes as source-sink relationship of carbohydrate determines trees vegetative and reproductive growth (Flore & Lakso, 1986; Goldschmidt 1999). Similar findings regarding less summer and fall flushes were observed in current work. Present results agree with the evidence that developing fruits strive for photoassimilates (Goldschmidt & Koch, 1996).

Fruit yield and grades percentage

Yield parameters including total no. of fruits, A-grade, B- grade and C- grade fruits harvesting per plant are presented in Table 4 which possessed significant differences.

In first season, total number of fruits per plant (755, 984 and 735 fruits), A-grade fruits (18.28, 13.88 and 10.43%), B-grade fruits (44.24, 45.52 and 48.23%) and C-grade fruits (37.48, 40.06 and 41.34%) were counted at Sargodha, TTS and Vehari, respectively. In second season, total number of fruits per plant (725, 650 and 467 fruits), A-grade (15.4, 9.46 and 8.71%), B-grade (39.87, 53.19 and 56.36%) and C-grade (44.64, 37.35 and 34.93%) were harvested in districts Sargodha, TTS and Vehari, respectively. Non-significant difference in yield parameters was observed at Sargodha during both seasons of depicting minute phenomena of biennial bearing. However, a significant

Table 4. Yield trend in biennial bearing under varying environmental conditions

Yield parameters	Sargodha		T.T Singh		Vehari	
	First season	Second season	First season	Second season	First season	Second season
No. of fruits/plant*	755.51±10.61	725.34±12.27	984.54±23.46	650.61±11.49	735.97±25.41	467.28±29.26
A-grade%	18.28±1.25	15.49±2.58	13.88±1.22	9.46±2.32	10.43±2.43	8.71±3.42
B-grade%	44.24±5.14	39.87±6.30	45.52±3.42	53.19±6.23	48.23±4.04	56.36±5.03
C-grade%	37.48±9.29	44.64±8.28	40.6±5.13	37.35±3.12	41.34±3.75	34.93±3.23

Data are shown in mean (±SD). *A, B and C (Grade-A, Grade-B and Grade-C).

difference was observed in first and second seasons in Kinnow fruit yield at TTS and Vehari of indicating more biennial bearing habit of orchard.

Fruit yield and quality is affected at the time of fruit growth due to climate variables (Yakushiji et al., 1996) and citrus fruit yield reduced to 1/4th in global warming (Zekri & Rouse, 2002), besides being observing deterioration in fruit quality (Holland et al., 2002). In current work, more quality deterioration was recorded at TTS and Vehari. Temperature was recorded more at Vehari, low fruit-setting and more premature drop was observed in both biennial bearing habits. In first season, fruit overall yield and quality like fruit grades were better due to more number of fruit while in second season, yield and grades percentage was reduced. In Sargodha, timely harvesting and medium-bearing habit maintained a source-sink relation which was further enhanced by moderate temperature and more chilling hour to retard biennial bearing tendency. Fruit A-grade quality is based on size and cosmetic outlook i.e., free from peel blemishes induced by abiotic (wind scares) and biotic (pest-diseases) incidences. More A-grade fruits were recorded at Sargodha and less at Vehari in first and second season of indicating stress on fruit quality in both districts. Pests pressure was more at Vehari while less at Sargodha and vice versa in disease case. Biennial bearing also affected fruit yield parameters including grading quality as was observed in present study which in line with the work of Chelong & Sdoodee (2013) on Shogan (*Citrus reticulata* Blanco) in Thailand.

Orchard harvesting trend

Orchards harvesting trend was surveyed in three different districts of the Punjab, presented in Table 5. At the end of January, more orchards were harvested at Sargodha (50 and 55%), followed by TTS (40 and 60%) and less at Vehari (30 and 36%) in first season and second season, respectively. Similar trend of more orchards harvesting

was observed in the end of February by recording at Sargodha (80 and 85%), TTS (75 and 86%) and Vehari (65 and 75%) in first and second seasons, respectively. At 15th March, maximum harvesting was done in Sargodha (98 and 100%), followed by TTS (93 and 97%) and minimum in Vehari (92 and 96%) in first and second season, respectively.

Delayed harvesting in avocado reduced yield and initiated alternate bearing (Whiley et al., 1996) with same trend was seen at TTS and Vehari. As harvesting was delayed, more biennial bearing was seen in these districts as compared to Sargodha where timely harvesting retard this phenomena. Fruit bearing affects plant metabolic processes involving coenzymes, sugars and amino acids (Nishikawa et al., 2016) and late harvesting accelerated it and affected next season crop. Late harvesting in both Vehari and TTS during heavy bearing crop resulted in low crop in next year and timely harvesting in Sargodha has reduced effect of alternate bearing. In Sargodha, well-established processing units for export have positive effects on timely picking of ripened fruits while in rest of two districts fruits harvesting depend on local markets and during on-year bearing period, more glut in market and low price have forced to delay harvesting until reasonable response from market. At first day of March, in Sargodha district maximum orchards were harvested with no effect on flowering of next crop while late at TTS and Vehari affected fruit-setting.

Fruit drop trend

Perusal of data regarding fruit drop in three different stages are presented in Table 6, in first and second seasons.

Physiological fruit drop was recorded in Sargodha (51.61 and 49.25%), TTS (54.82 and 51.21%) and Vehari (51.42 and 48.2%) in first and second season, respectively. Rainy season (June-September), fruit drop was recorded at Sargodha (25.22 and 22.35%), TTS (19.6 and 16.2%) and Vehari (18.36 and 15.32%) in first and second season,

Table 5. Kinnow orchards harvesting trend in biennial bearing under varying environmental conditions

	Orchards harvesting trend in selected Kinnow fruit clusters					
	Sargodha		T.T Singh		Vehari	
	First season	Second season	First season	Second season	First season	Second season
End of January (%)	50±3.25	55±4.14	40±3.65	60±4.15	30±5.36	36±4.08
End of February (%)	80±2.95	85±3.21	75±2.89	86±3.42	65±3.45	75±5.02
Midst of March (%)	96±1.84	98±1.02	95±1.84	97±1.21	93±2.11	95±2.48

Data are shown in mean (±SD). SD = standard deviation.

Table 6. Kinnow fruit drop trend in biennial bearing under varying environmental conditions

	Fruit drop trend in selected Kinnow fruit clusters					
	Sargodha		T.T Singh		Vehari	
	First season	Second season	First season	Second season	First season	Second season
Physiological fruit (%)	51.61±2.85	49.25±3.04	54.82±3.15	51.21±3.05	51.42±3.46	48.2±3.28
Rainy season drop (%)	25.22±3.15	22.35±4.11	19.6±2.17	16.2±2.12	18.36±2.45	15.32±2.02
Maturing phase drop (%)	11.77±2.24	9.92±2.12	16.4±2.64	14.95±2.23	20.19±2.11	18.24±3.18
Total drop (Apr-Dec) (%)	88.6±4.14	81.52±2.12	90.82±2.64	82.36±4.03	89.97±3.21	81.76±2.12

Data are shown in mean (±SD). SD = standard deviation.

respectively. Maturing stage (October-December), fruit drop was noted at Sargodha (11.77 and 9.92%), TTS (16.4 and 14.95%) and Vehari (20.19 and 18.24%) in first and second season, respectively. Total fruit drop remained non-significant among three districts but shown significant differences in both seasons.

Thind & Kumar (2008) reported physiological drop (40-63%) and pathological drop (5-25%) in Kinnow mandarin. Physiological fruit drop remained dominant just after fruit-setting till cell division stage, whereas pathological fruit drop continued July till harvesting (Kumar et al., 2011). Excessive premature fruit drop was linked with environmental factors; plant nutrition and water requirement (Ibrahim et al., 2007; Ashraf et al., 2010) and pests pressure (Razi et al., 2011). In all three districts, physiological drop (April-May) was recorded as maximum when fruit cell division phase is ongoing just after fruit-setting, followed by intense heat-wave to increase plant water requirement as require to compensate carbohydrates (sink-source relation). In warm conditions of TTS and Vehari, more physiological fruit drop was observed as compared to Sargodha where rainy season resulted in more drop. Climate change has increased temperature in autumn season with increased humidity and smog/fog phenomenon that become more suitable for stem-end rot and fruit fly infestation, hence more drop was recorded in TTS and Vehari in autumn months when fruit maturing process occurred. Climatic variability in three

locations led to more fruit drop in one or other way to influence on either physiological or pathological drops in Kinnow mandarin while inducing biennial bearing trend.

CONCLUSION

More biennial trend was seen in warm districts TTS and Vehari due to erratic behavior of weather round the year. Climatic variables influenced on fruit growth and finally on yield and quality by recording unevenness at TTS and Vehari. Harvesting time and balance in plant source-sink relation decide regular yield. Biennial bearing, an inherent phenomenon of citrus, is directly influenced by environmental factors and also induced stress by climate change. Present study has highlighted main reasons of biennial bearing will be useful in future to achieve regular bearing of fruit while doing timely harvesting and management of orchard.

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